Center Innovation Fund: GSFC CIF

Gravity Independence of Microchannel Two-Phase Flow

Completed Technology Project (2013 - 2014)

Project Introduction

Highly integrated electronic systems and onboard processing capabilities are critical to future NASA missions, but their development and operation is constrained by poor thermal management. Compact, two-phase coolers offer the heat transport capacity, small volume, low mass, and low power consumption necessary to efficiently remove heat from these systems, but the present lack of understanding of boiling heat transfer in microchannels in microgravity severely limits NASA's implementation of this technology. The hypothesis is that in microchannel flow boiling, shear and surface tension forces dominate and gravitational forces play a minor role. The proposed effort will systematically determine the microchannel two-phase flow conditions for which the flow behavior is gravity independent.

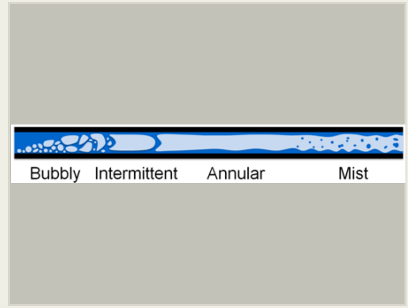
Most of the amassed two-phase flow and heat transfer knowledge comes from experiments conducted in Earth’s gravity. Space missions span varying gravity levels, thus demanding thorough understanding of gravitational effects on two-phase flow. Alternatively, it is believed that in microchannel flow boiling, shear and surface tension forces dominate thermal and momentum transport and gravitational forces play a minor role. The multi-year effort will systematically explore the dependence of microchannel two-phase flow behavior on gravitational acceleration and determine the flow parameters for which the effect of gravitational force is insignificant. This objective requires the development and assembly of a state-of-the-art flow boiling test facility that can be rotated relative to earth's gravitational acceleration vector and can be installed in a plane capable of achieving variable gravity via parabolic maneuvers.

Measurements from the test facility will enable calculation of critical heat flux, local heat transfer coefficients, and pressure drop, all of which can be compared to existing correlations for flow boiling in microchannels in terrestrial gravity to assess gravity effects. Visualization of the evaporator using a high-speed camera will provide flow pattern assessments that will be correlated with measurements and calculations. Several recent studies provide evidence of the link between flow regimes and key two-phase parameters and inspire confidence that regime-informed approaches can improve the predictive accuracy of two-phase formulations.

The goals of the ground studies are to identify boundaries separating gravity-dependent and gravity-insensitive two-phase flows and to identify boundaries separating flow regimes and determine the extent to which these boundaries are applicable to different boiling phenomena like pressure drop, heat transfer coefficients, and critical heat flux. The results from the ground studies will be validated via testing in reduced gravity.

Anticipated Benefits

This research, if successful, will dramatically reduce testing costs for



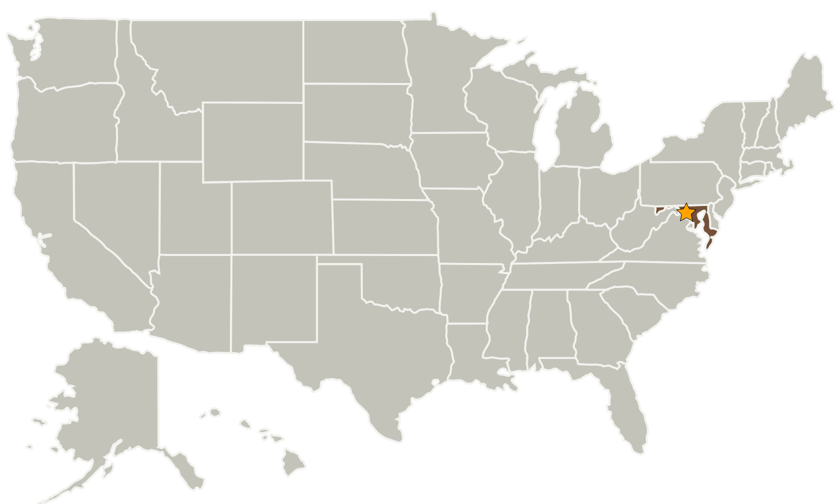
Gravity Independence of Microchannel Two-Phase Flow Project

Table of Contents

two-phase systems employing microchannels because flight testing will not be required (i.e., these results will instill confidence that ground-based and flight performance of these systems will be very similar). Furthermore, this research will enable cooling of high heat flux electronic chips and chip stacks (>100W/cm^2) critical to NASA's onboard processing needs.

This project, if successful, could benefit other government agencies that rely on two-phase cooling systems in reduced gravity (e.g., lunar environment) or hyper gravity environments (e.g., aircraft). High heat flux cooling of electronics (or other power dense devices) in vehicles that maneuver at high acceleration is an area that would benefit greatly from the successful completion of this work as this work could prove that two-phase cooling systems employing microchannel evaporators are relatively insensitive to g-load, thus enabling more widespread implementation of this advanced thermal management technique.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Innovation Fund: GSFC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Peter M Hughes

Project Manager:

Theodore D Swanson

Principal Investigator:

Franklin L Robinson

Primary U.S. Work Locations

Maryland

Images

Gravity Independence of Microchannel Two-Phase Flow Project
Gravity Independence of Microchannel Two-Phase Flow Project
(https://techport.nasa.gov/image/4089)

Project Website:

http://aetd.gsfc.nasa.gov/

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **2**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX14 Thermal Management Systems
  └ TX14.2 Thermal Control Components and Systems
    └ TX14.2.2 Heat Transport